General

Guideline Title

ACR Appropriateness Criteria® acute trauma to the knee.

Bibliographic Source(s)

Tuite MJ, Kransdorf MJ, Beaman FD, Adler RS, Amini B, Appel M, Bernard SA, Dempsey ME, Fries IB, Greenspan BS, Khurana B, Mosher TJ, Walker EA, Ward RJ, Wessell DE, Weissman BN, Expert Panel on Musculoskeletal Imaging. ACR Appropriateness CriteriaÂ® acute trauma to the knee [online publication]. Reston (VA): American College of Radiology (ACR); 2014. 11 p. [67 references]

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Tuite MJ, Daffner RH, Weissman BN, Bancroft L, Bennett DL, Blebea JS, Bruno MA, Fries IB, Hayes CW, Kransdorf MJ, Luchs JS, Morrison WB, Roberts CC, Scharf SC, Stoller DW, Taljanovic MS, Ward RJ, Wise JN, Zoga AC, Expert Panel on Musculoskeletal Imaging. ACR Appropriateness Criteria® acute trauma to the knee. [online publication]. Reston (VA): American College of Radiology (ACR); 2011. 9 p. [61 references]

This guideline meets NGC's 2013 (revised) inclusion criteria.

Recommendations

Major Recommendations

ACR Appropriateness Criteria®

Clinical Condition: Acute Trauma to the Knee

Variant 1: Adult or child >1 year old. Fall or twisting injury, no focal tenderness, no effusion; able to walk. First study.

Radiologic Procedure	Rating	Comments	RRL*
X-ray knee	2		
MRI knee without contrast	2		O
MRI knee without and with contrast	1		O
US knee	1		O

Radiologic Procedure	Rating	Comments	RRL*
MRA knee without and with contrast	1		O
MRA knee without contrast	1		O
CT knee without contrast	1	The RRL for the adult procedure is .	
CT knee with contrast	1	The RRL for the adult procedure is .	
CT knee without and with contrast	1	The RRL for the adult procedure is .	
Tc-99m bone scan with SPECT lower extremity	1		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the table are listed at the end of the "Major Recommendations" field.

Variant 2: Adult or child >1 year old. Fall or twisting injury, with one or more of following: focal tenderness, effusion, inability to bear weight. First study.

Radiologic Procedure	Rating	Comments	RRL*
X-ray knee	9		
MRI knee without contrast	5		O
US knee	2		O
CT knee without contrast	2	The RRL for the adult procedure is .	
Tc-99m bone scan with SPECT lower extremity	2		
MRI knee without and with contrast	1		O
MRA knee without and with contrast	1		O
MRA knee without contrast	1		O
CT knee with contrast	1	The RRL for the adult procedure is .	
CT knee without and with contrast	1	The RRL for the adult procedure is .	
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 3: Adult or child >1 year old. Fall or twisting injury with either no fracture or a Segond fracture seen on a radiograph, suspect internal derangement. Next study.

Radiologic Procedure	Rating	Comments	RRL*
MRI knee without contrast	9		O
CT knee without contrast	5	The RRL for the adult procedure is .	
US knee	1		O
MRI knee without and with contrast	1		O
MRA knee without and with contrast	1		O
MRA knee without contrast	1		O
CT knee with contrast	1	The RRL for the adult procedure is .	
CT knee without and with contrast	1	The RRL for the adult procedure is .	
Tc-99m bone scan with SPECT lower extremity	1		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 4: Adult or child >1 year old. Fall or twisting injury with a tibial plateau fracture on a radiograph, with additional bone or soft-tissue injury suspected. Next study.

Radiologic Procedure	Rating	Comments	RRL*
CT knee without contrast	9	This procedure may be helpful for treatment planning or prognosis. The RRL for the adult procedure is .	
MRI knee without contrast	7		O
US knee	1		O
MRI knee without and with contrast	1		O
MRA knee without and with contrast	1		O
MRA knee without contrast	1		O
CT knee with contrast	1	The RRL for the adult procedure is .	
CT knee without and with contrast	1	The RRL for the adult procedure is .	
Tc-99m bone scan with SPECT lower extremity	1		
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation

Radiologic Procedure	Rating	Comments	Level RRL*

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 5: Adult or child >1 year old. Injury to knee, mechanism unknown. Focal patellar tenderness, effusion, able to walk.

Radiologic Procedure	Rating	Comments	RRL*
X-ray knee	9	Consider this procedure if it was not previously obtained or if patella views were not included.	
MRI knee without contrast	5		O
US knee	2		O
CT knee without contrast	2	The RRL for the adult procedure is .	
Tc-99m bone scan with SPECT lower extremity	2		
MRI knee without and with contrast	1		O
MRA knee without and with contrast	1		O
MRA knee without contrast	1		O
CT knee with contrast	1	The RRL for the adult procedure is .	
CT knee without and with contrast	1	The RRL for the adult procedure is .	
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 6: Adult or child >1 year old. Significant trauma to the knee from motor vehicle accident, suspect knee dislocation.

Radiologic Procedure	Rating	Comments	RRL*
X-ray knee	9	This procedure should be an initial examination to assess overall injury. A normal x-ray does not preclude further imaging workup for vascular or ligament injury.	
MRI knee without contrast	9	This procedure is necessary to evaluate the extent of damage to ligaments and other support structures.	O
MRA knee without and with contrast	7	This procedure should be performed in conjunction with MRI of the knee.	O
Arteriography lower extremity	7	The RRL for the adult procedure is .	
CTA lower extremity with contrast	7	This procedure should be performed in conjunction	*Relative Radiation

Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

Radiologic Procedure	Rating	Comments	RRL*
		with trauma CT imaging. The RRL for the adult procedure is .	
MRA knee without contrast	3	This procedure should be performed in conjunction with MRI of knee.	O
US knee	2		O
CT knee without contrast	2	The RRL for the adult procedure is .	
Tc-99m bone scan with SPECT lower extremity	2		
MRI knee without and with contrast	1		O
CT knee with contrast	1	The RRL for the adult procedure is .	
CT knee without and with contrast	1	The RRL for the adult procedure is .	
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Summary of Literature Review

Introduction/Background

A 2010 report stated that there are 500,000 visits per year to United States emergency departments because of acute knee trauma. In the pediatric and adolescent population, knee pain is the second most common musculoskeletal complaint and the most common sports-related injury seen in emergency departments.

Overview of Imaging Modalities

Radiography

Several studies have found that the knee radiograph is commonly obtained after trauma in the emergency room but has the lowest yield for diagnosing clinically significant fractures. Other studies have shown that only about 5% of patients with acute knee trauma have a fracture on radiographs, and that one-fourth of all findings seen on knee radiographs do not correlate with clinical findings. Despite this, many acute care clinicians continue to obtain them. The reasons cited include 1) patient expectations, 2) demands of orthopedic consult, 3) lack of confidence in physical examination, and 4) fear of being sued.

Clinical decision rules for the acutely injured knee suggest that radiographic examination of the knee following acute injury can be eliminated in most instances by applying specific clinical guidelines. Two of the most common clinical decision rules are the Ottawa Knee Rule and the Pittsburgh Decision Rule.

The Ottawa Knee Rule states that patients ≥18 years old with acute knee pain should have knee radiographs if they meet any of the following criteria:

- Are 55 years of age or older
- Have palpable tenderness over the head of the fibula
- Have isolated patellar tenderness
- Cannot flex the knee to 90º
- Cannot bear weight immediately following the injury, or

- Cannot walk in the emergency room (after taking four steps)

One study applied the rule prospectively in 1,047 adults with acute knee injuries, and it was determined that its application would maintain a 100% sensitivity for fracture while resulting in a 28% relative reduction in the number of radiographs ordered, a decrease from 68.6% to 49.4%. A later study analyzing 1,096 patients found it to be 100% sensitive for identifying knee fractures. The decision rule was interpreted correctly 96% of the time and, when applied, the probability of missing a fracture was zero. A prospective analysis by a group of authors also showed that it allowed a decrease in the number of radiographs performed after knee trauma by 35%, with a sensitivity of knee fracture detection of 100%. Another study found a similar 23% reduction in 90 patients if the rules were applied, although they did report one patient who had a fracture but did not meet any of the clinical criteria. However, the fracture was radiographically occult and visible only on magnetic resonance imaging (MRI). An additional study applied the rules to 146 children under 18 and found it would have decreased the number of radiographs by 39% while maintaining 100% sensitivity. In a pooled analysis of data from 6 studies, it was concluded that a negative result using the Ottawa Knee Rule accurately excluded knee fracture after acute knee injury.

The Pittsburgh Decision Rule says that patients with acute knee trauma who are <12 years old or >50 years old should receive a radiograph, as well as patients who cannot take 4 weight-bearing steps in the emergency department. One study reported a 92% sensitivity and 79% specificity for identifying clinically significant fractures. That study also reported that applying the clinical decision rules could reduce the number of radiographs taken in the emergency room by 78%. Another study also found a potential 52% reduction in the number of radiographs, again with the one false-negative radiographically occult fracture.

Other clinical decision rules have also been investigated. One study concluded that a clinically significant fracture can be excluded in patients older than 18 years who can walk without limping or if there was a twisting injury to the knee and no joint effusion. If an effusion was present on physical examination, the odds of a fracture were 7.5 times greater. Using this clinical decision rule, the sensitivity for detecting a knee fracture was 100%, and specificity was sufficient to eliminate the need for 29% of knee radiographs ordered in the emergency room. Another study of 146 patients <18 years old found a potential 53% reduction in radiographs if applying only the criteria of ability to take 4 weight-bearing steps in the emergency department.

A meta-analysis to determine the role of radiography in evaluating knee fractures concluded that among the 5 decision rules evaluated, the Ottawa Knee Rule had the strongest supporting evidence. Another study compared the implementation of the Ottawa Knee Rule by triage nurses and emergency medicine physicians. No fracture was missed by either group, but triage nurses were found to order 3.6 times more radiographs than emergency physicians, maintaining sensitivity at the expense of specificity and cost savings.

The mechanism of injury as determined by history and physical examination can be helpful when deciding if a decision rule should be applied. The most common mechanisms for knee injury are a direct blow, a fall, or a twisting injury. Twisting injuries are responsible for three-fourths of all knee injuries; however, 86% of all knee fractures result from blunt trauma. The risk of fracture also increases with age; fracture is four times more likely in patients >50 years old, presumably secondary to osteoporosis, increased frequency of blunt injury, and inability to protect the knee during a fall. Conversely, absence of immediate swelling, ecchymosis, effusion, deformity, increased warmth, and abrasion/laceration is a significant predictor of a normal radiograph.

Clinicians should be cautious relying on a nonsystematic clinical examination for diagnosing certain knee injuries, however. One study reported that the correct diagnosis of bilateral quadriceps tendon rupture was established in only 61% (17/28) of cases by history and clinical examination alone. Another study reported that fractures missed on clinical examination included fractures of the patella, tibial spine, and fibular head.

Magnetic Resonance Imaging

In addition to clinically significant fractures, other injuries must be considered in patients with acute knee pain. Most patients (93.5%) who present with acute knee injuries in the emergency room have soft-tissue rather than osseous injuries. MRI is a valuable tool in the decision-making process, altering the treatment plan and allowing earlier surgical intervention by obtaining a more accurate diagnosis. A study showed that the first clinical examination after acute knee trauma has a low diagnostic value, and that the incidence of anterior cruciate ligament (ACL) injuries on MRI is higher than initially suspected. In randomized studies of patients with knee injuries, MRI findings have been shown to shorten the time to completion of diagnostic workup, reduce the number of additional diagnostic procedures, improve quality of life in the first 6 weeks, and potentially reduce costs associated with lost productivity. Another study showed that the presence of a bone contusion on MRI after acute trauma is highly predictive of the development of focal osteoarthritis 1 year after trauma. Although a locked knee has been described as an indication to go directly to arthroscopy, MRI can change management from surgical to conservative in up to 48% of patients. It should be noted that MRI should be read with caution in trauma patients without mechanical signs who have osteoarthritis.

Computed Tomography

Computed tomography (CT) with three-dimensional (3-D) reconstruction has been compared to knee radiographs and shown to be more sensitive

for fracture, 100% versus 83% for radiographs, and to reflect the severity of tibial plateau fractures more accurately. In severely injured patients, diagnostically sufficient radiographs are sometimes difficult to obtain, and therefore a negative radiograph is not reliable in ruling out a fracture. In these patients, multidetector CT is a fast and accurate examination for evaluating tibial plateau fractures and other complex knee injuries. A group of researchers concluded that in the acute setting, CT offers 80% sensitivity and 98% specificity for depicting osseous avulsions and a high negative predictive value for excluding ligament injury. Another group found that the amount of articular surface depression on CT is a predictor of meniscus and ligament injuries and can identify when an MRI is indicated.

Dual-energy CT has recently shown that it can detect post-traumatic bone marrow lesions or bone contusions. Dual-energy CT may be more useful than single-energy CT in assessing knee trauma because it can not only show subtle fractures, but it can also demonstrate bone contusions that are markers of meniscus and ligament injuries.

Single Photon Emission Computed Tomography

Single photon emission computed tomography (SPECT) has been proposed for diagnosing meniscus injuries. A specific crescentic pattern of uptake on the transaxial view has been described as having a sensitivity of 77% and specificity of 74%. With the additional criterion of increased equilibrium activity in the adjacent femoral condyles, these values increase to 90% and 84%, respectively. Considerable concordance has been shown between SPECT results and those of other modalities for assessing meniscal tears and the bone contusions from an ACL tear in acute knee trauma.

Ultrasound

Sonography has been reported to be 91% sensitive and 100% specific for diagnosing an acute ACL tear within 10 weeks of an acute hemarthrosis when there is no prior trauma and no bone abnormalities. Furthermore, a comparison of sonography and radiography using lipohemarthrosis as a criterion of acute intra-articular fracture yielded a sensitivity and specificity of 94% for sonographic detection of such fractures. One study showed that the presence of an effusion at sonography in the acutely injured knee has a 91% positive predictive value for internal derangement. Another study reported an 85% sensitivity and 86% specificity for meniscal tears, with the specificity highest in recent injuries (<1 month). However, intra-articular knee sonography should only be performed and interpreted by personnel with the appropriate expertise in its application.

Discussion of Imaging Modalities by Variant

Variants 1 and 2: Adult or child >1 year old. Fall or twisting injury. First study.

Clinical decision rules, such as the Ottawa Knee Rule or the Pittsburgh Decision Rule described above, are well-validated and have been shown to reduce the number of radiographs obtained for acute knee trauma while still identifying almost all patients who have a fracture. It is generally agreed that radiographs should be obtained and the clinical decision rule should not be applied for patients with gross deformity, a palpable mass, a penetrating injury, prosthetic hardware, an unreliable clinical history or physical examination secondary to multiple injuries, altered mental status (e.g., head injury, drug or alcohol use, dementia), neuropathy (e.g., paraplegia, diabetes), or a history suggesting increased risk of fracture. The physician's judgment and common sense, however, should supersede clinical guidelines.

Variant 3: Adult or child >1 year old. Fall or twisting injury with either no fracture or a Segond fracture seen on a radiograph, suspect internal derangement. Next study.

MRI is considered the optimal imaging modality for identifying meniscal, ligament, chondral, and nondisplaced bone injuries around the knee. Numerous studies have shown that MRI has a high diagnostic accuracy in identifying traumatic intra-articular knee lesions. This is particularly true when strict diagnostic criteria are used, and this applies to both spin-echo imaging and fast spin-echo imaging as well as imaging at both low and high field strength. Characteristic imaging patterns on MRI, including specific patterns of bone marrow edema and osteochondral injuries, help make MRI highly accurate for even subtle ligament and meniscal injuries.

Variant 4: Adult or child >1 year old. Fall or twisting injury with a tibial plateau fracture on a radiograph, with additional bone or soft-tissue injury suspected. Next study.

Some tibial plateau fractures can be adequately assessed and a treatment decision made using radiographs only. For more complex fractures, CT and MRI are helpful for complete injury assessment and for presurgical planning. The advantage of CT is that it shows cortical bone detail well, is easier to obtain if a CT scanner is near the emergency department, has a shorter total scan time (important in severely injured patients), and has a lower cost. The advantage of MRI is that it can demonstrate soft tissue and bone marrow injuries while adequately demonstrating many cortical bone fractures. Soft-tissue injuries are common in many patients with knee fractures. One study reported unstable meniscal tears in 36% of patients with tibial plateau fractures. Another study found a meniscus tear in 49% and at least one ligament tear in 71%, of patients with a tibial plateau fracture.

Variant 5: Adult or child >1 year old. Injury to knee, mechanism unknown. Focal patellar tenderness, effusion, able to walk.

Patellar pain after trauma can be from several causes, including patellar fracture and transient patellar dislocation. For patellar fractures, radiographs should include a patellar view such as a sunrise view in addition to anterior posterior and lateral radiographs.

Transient patellar dislocation is unsuspected clinically in 45% to 73% of patients with evidence of dislocation subsequently seen on MRI. Radiographs may demonstrate a fracture of the medial patella or lateral trochlear and can also show anatomic features that predispose to dislocation such as a decreased sulcus angle, patella alta, patellar tilt, or patellar subluxation. MRI is more sensitive than radiographs for imaging findings of lateral patellar dislocation, including injury to the medial patellofemoral ligament, bone contusions, and osteochondral injuries.

Variant 6: Adult or child >1 year old. Significant trauma to knee from motor vehicle accident, suspect knee dislocation.

Dislocation of the knee is uncommon, representing about 0.1% of orthopedic injuries. The injury typically results from a motor vehicle accident, but can also occur from contact sports, a vehicle striking a pedestrian, falls, or even a spontaneous dislocation in morbidly obese individuals. In 14% to 44% of patients the dislocation is part of multiple traumatic injuries. This injury, which may reduce spontaneously, constitutes a true orthopedic emergency because of possible nerve or arterial damage. Vascular injury may be found in about 30% of patients following posterior knee dislocation. Physical signs of clinically significant vascular injury are the absence of pulses, ischemia, active bleeding, and bruit/thrill. Although angiography is considered the gold standard for assessing for vascular injury, there is some debate whether it should be obtained in all knee dislocation patients or be used selectively. Computed tomography angiography (CTA) is increasingly being used because it is less invasive, has a similar high accuracy, and involves a lower radiation dose.

MR angiography (MRA) has also been shown to be an accurate technique for assessing for vascular injury after knee dislocation. Some authors recommend MRA because the patient can also have a diagnostic knee MR examination at the same time to assess for the extent of ligament injury. A group of authors found excellent correlation between MRI findings and surgical findings in patients with knee dislocation. Furthermore, these authors reported 100% correlation between MRA findings and conventional angiography findings in multiple-ligament injured knees, including knee dislocations.

Summary of Recommendations

Clinical decision rules for evaluating the acutely injured knee have been studied by various investigators, who determined that their application can considerably reduce the number of radiographs ordered without missing a clinically significant fracture. Although different parameters and definitions were used for the various decision rules, there were sufficient similarities between the investigations to allow usable conclusions to be drawn.

In patients of any age except for infants, the clinical parameters used for *not requiring* radiographs following knee trauma are as follows:

- Patient is able to walk without a limp
- Patient had a twisting injury, and there is no effusion

The clinical parameters for *ordering* knee radiographs in this population following trauma are as follows:

- Joint effusion within 24 hours of direct blow or fall
- Palpable tenderness over the fibular head or patella
- Inability to walk (4 steps) or bear weight immediately or in the emergency room or within a week of the trauma
- Inability to flex knee to 90º
- Altered mental status

In general, these studies excluded patients with superficial skin injuries, gross deformity, a palpable mass, a penetrating injury, prosthetic hardware, altered consciousness (from alcohol and/or drug use), multiple injuries, decreased limb sensation, or a history indicating an elevated risk of fracture. They also excluded pregnant patients, patients returning for reassessment, and patients whose injury occurred more than 7 days prior to initial evaluation.

Soft-tissue injuries (meniscal injuries, chondral surface injuries, and ligamentous disruption) are best evaluated by MRI. Although lateral patellar dislocation may be reduced at the time of presentation in the emergency room, characteristic findings on MRI, including specific bone marrow edema patterns and osteochondral defects, can allow accurate diagnosis.

Knee dislocation, even if spontaneously reduced, constitutes a potential threat to the popliteal nerve or artery. Studies have suggested that the isolated presence of abnormal pedal pulses on initial examination following knee dislocation is not sensitive enough to detect a vascular injury that necessitates surgery, and that the workup should include angiography. One study has shown a 100% correlation between MRA findings and

conventional angiography findings in multiple-ligament injured knees, including knee dislocations. An MRI should also be performed to identify ligamentous injuries and associated pathology dislocation.

Abbreviations

- CT, computed tomography
- CTA, computed tomography angiography
- MRA, magnetic resonance angiography
- MRI, magnetic resonance imaging
- SPECT, single photon emission computed tomography
- Tc-99m, technetium-99 metastable
- US, ultrasound

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
	<0.1 mSv	<0.03 mSv
	0.1-1 mSv	0.03-0.3 mSv
	1-10 mSv	0.3-3 mSv
	10-30 mSv	3-10 mSv
	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."		

Clinical Algorithm(s)

Algorithms were not developed from criteria guidelines.

Scope

Disease/Condition(s)

Acute trauma to the knee

Guideline Category

Diagnosis

Clinical Specialty

Emergency Medicine

Family Practice

Internal Medicine

Nuclear Medicine

Orthopedic Surgery

Pediatrics

Radiology

Intended Users

Health Plans

Hospitals

Managed Care Organizations

Physicians

Utilization Management

Guideline Objective(s)

To evaluate the appropriateness of various imaging modalities for the initial examination of patients with acute trauma to the knee

Target Population

Adults or children >1 year of age with acute trauma to the knee

Interventions and Practices Considered

1. X-ray, knee
2. Magnetic resonance imaging (MRI), knee
    - Without contrast
    - Without and with contrast
3. Ultrasound (US), knee
4. Magnetic resonance angiography (MRA), knee
    - Without and with contrast
    - Without contrast
5. Computed tomography (CT), knee
    - Without contrast
    - With contrast
    - Without and with contrast
6. Technetium-99 metastable (Tc-99m) bone scan with single photon emission computed tomography (SPECT), lower extremity
7. Arteriography, lower extremity
8. Computed tomography angiography (CTA), lower extremity with contrast

Major Outcomes Considered

- Utility of radiologic examinations in differential diagnosis
- Sensitivity and specificity of radiologic examination
- Reduction in number of radiographs ordered

Methodology

Methods Used to Collect/Select the Evidence

Hand-searches of Published Literature (Primary Sources)

Hand-searches of Published Literature (Secondary Sources)

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence

Literature Search Summary

Of the 61 citations in the original bibliography, 36 were retained in the final document. Articles were removed from the original bibliography if they were more than 10 years old and did not contribute to the evidence or they were no longer cited in the revised narrative text.

Two new literature searches were conducted in July 2013 and August 2014 to identify additional evidence published since the *ACR Appropriateness Criteria® Acute Trauma to the Knee* topic was finalized. Using the search strategies described in the literature search companion (see the "Availability of Companion Documents" field), 74 articles were found. Four articles were added to the bibliography. Seventy articles were not used due to either poor study design, the articles were not relevant or generalizable to the topic, the results were unclear, misinterpreted, or biased, or the articles were already cited in the original bibliography.

The author added 27 citations from bibliographies, Web sites, or books that were not found in the new literature searches.

See also the American College of Radiology (ACR) Appropriateness Criteria® literature search process document (see the "Availability of Companion Documents" field) for further information.

Number of Source Documents

Of the 61 citations in the original bibliography, 36 were retained in the final document. The new literature search conducted in July 2013 and August 2014 identified four articles that were added to the bibliography. The author added 27 citations from bibliographies, Web sites, or books that were not found in the new literature searches.

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Study Quality Category Definitions

Category 1 - The study is well-designed and accounts for common biases.

Category 2 - The study is moderately well-designed and accounts for most common biases.

Category 3 - There are important study design limitations.

Category 4 - The study is not useful as primary evidence. The article may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus. For example:

a. The study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description).
b. The study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence.
c. The study is an expert opinion or consensus document.

Methods Used to Analyze the Evidence

Review of Published Meta-Analyses

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

The topic author assesses the literature then drafts or revises the narrative summarizing the evidence found in the literature. American College of Radiology (ACR) staff drafts an evidence table based on the analysis of the selected literature. These tables rate the study quality for each article included in the narrative.

The expert panel reviews the narrative, evidence table and the supporting literature for each of the topic-variant combinations and assigns an appropriateness rating for each procedure listed in the variant table(s). Each individual panel member assigns a rating based on his/her interpretation of the available evidence.

More information about the evidence table development process can be found in the ACR Appropriateness Criteria® Evidence Table Development documents (see the "Availability of Companion Documents" field).

Methods Used to Formulate the Recommendations

Expert Consensus (Delphi)

Description of Methods Used to Formulate the Recommendations

Rating Appropriateness

The American College of Radiology (ACR) Appropriateness Criteria (AC) methodology is based on the RAND Appropriateness Method. The appropriateness ratings for each of the procedures or treatments included in the AC topics are determined using a modified Delphi method. A series of surveys are conducted to elicit each panelist's expert interpretation of the evidence, based on the available data, regarding the appropriateness of an imaging or therapeutic procedure for a specific clinical scenario. The expert panel members review the evidence presented and assess the risks or harms of doing the procedure balanced with the benefits of performing the procedure. The direct or indirect costs of a procedure are not considered as a risk or harm when determining appropriateness. When the evidence for a specific topic and variant is uncertain or incomplete, expert opinion may supplement the available evidence or may be the sole source for assessing the appropriateness.

The appropriateness is represented on an ordinal scale that uses integers from 1 to 9 grouped into three categories: 1, 2, or 3 are in the category "usually not appropriate" where the harms of doing the procedure outweigh the benefits; and 7, 8, or 9 are in the category "usually appropriate" where the benefits of doing a procedure outweigh the harms or risks. The middle category, designated "may be appropriate", is represented by 4, 5, or 6 on the scale. The middle category is when the risks and benefits are equivocal or unclear, the dispersion of the individual ratings from the group median rating is too large (i.e., disagreement), the evidence is contradictory or unclear, or there are special circumstances or subpopulations which could influence the risks or benefits that are embedded in the variant.

The ratings assigned by each panel member are presented in a table displaying the frequency distribution of the ratings without identifying which members provided any particular rating. To determine the panel's recommendation, the rating category that contains the median group rating without disagreement is selected. This may be determined after either the first or second rating round. If there is disagreement after the second rating round, the recommendation is "May be appropriate."

This modified Delphi method enables each panelist to articulate his or her individual interpretations of the evidence or expert opinion without excessive influence from fellow panelists in a simple, standardized and economical process. For additional information on the ratings process see the Rating Round Information document on the ACR Web site.

Additional methodology documents, including a more detailed explanation of the complete topic development process and all ACR AC topics can be found on the ACR Web site (see also the "Availability of Companion Documents" field).

Rating Scheme for the Strength of the Recommendations

Not applicable

Cost Analysis

The guideline developers reviewed published cost analyses.

Method of Guideline Validation

Internal Peer Review

Description of Method of Guideline Validation

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The recommendations are based on analysis of the current literature and expert panel consensus.

Summary of Evidence

Of the 67 references cited in the *ACR Appropriateness Criteria® Acute Trauma to the Knee* document, all of them are categorized as diagnostic references including 2 well-designed studies, 12 good quality studies, and 16 quality studies that may have design limitations. There are 37 references that may not be useful as primary evidence.

While there are references that report on studies with design limitations, 14 well-designed or good quality studies provide good evidence.

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

Selection of appropriate radiologic imaging procedures for evaluation of patients with acute trauma to the knee

Potential Harms

Relative Radiation Level

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults. Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document (see the "Availability of Companion Documents" field).

Qualifying Statements

Qualifying Statements

The American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Getting Better

IOM Domain

Effectiveness

Identifying Information and Availability

Bibliographic Source(s)

Tuite MJ, Kransdorf MJ, Beaman FD, Adler RS, Amini B, Appel M, Bernard SA, Dempsey ME, Fries IB, Greenspan BS, Khurana B, Mosher TJ, Walker EA, Ward RJ, Wessell DE, Weissman BN, Expert Panel on Musculoskeletal Imaging. ACR Appropriateness CriteriaÂ® acute trauma to the knee [online publication]. Reston (VA): American College of Radiology (ACR); 2014. 11 p. [67 references]

Adaptation

Not applicable: The guideline was not adapted from another source.

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Guideline Developer(s)

American College of Radiology - Medical Specialty Society

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Guideline Committee

Committee on Appropriateness Criteria, Expert Panel on Musculoskeletal Imaging

Composition of Group That Authored the Guideline

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Financial Disclosures/Conflicts of Interest

Not stated

Guideline Status

This is the current release of the guideline.

This guideline updates a previous version: Tuite MJ, Daffner RH, Weissman BN, Bancroft L, Bennett DL, Blebea JS, Bruno MA, Fries IB, Hayes CW, Kransdorf MJ, Luchs JS, Morrison WB, Roberts CC, Scharf SC, Stoller DW, Taljanovic MS, Ward RJ, Wise JN, Zoga AC, Expert Panel on Musculoskeletal Imaging. ACR Appropriateness Criteria® acute trauma to the knee. [online publication]. Reston (VA): American College of Radiology (ACR); 2011. 9 p. [61 references]

This guideline meets NGC's 2013 (revised) inclusion criteria.

Guideline Availability

Electronic copies: Available from the American College of Radiology (ACR) Web site.

Print copies: Available from the American College of Radiology, 1891 Preston White Drive, Reston, VA 20191. Telephone: (703) 648-8900.

Availability of Companion Documents

The following are available:

- ACR Appropriateness Criteria®. Overview. Reston (VA): American College of Radiology; 2015 Feb. 3 p. Electronic copies: Available from the American College of Radiology (ACR) Web site.
- ACR Appropriateness Criteria®. Literature search process. Reston (VA): American College of Radiology; 2015 Feb. 1 p. Electronic

copies: Available from the ACR Web site .

- ACR Appropriateness Criteria®. Evidence table development – diagnostic studies. Reston (VA): American College of Radiology; 2013 Nov. 3 p. Electronic copies: Available from the ACR Web site .
- ACR Appropriateness Criteria®. Radiation dose assessment introduction. Reston (VA): American College of Radiology; 2015 Feb. 3 p. Electronic copies: Available from the ACR Web site .
- ACR Appropriateness Criteria®. Procedure information. Reston (VA): American College of Radiology; 2015 Feb. 2 p. Electronic copies: Available from the ACR Web site .
- ACR Appropriateness Criteria® acute trauma to the knee. Evidence table. Reston (VA): American College of Radiology; 2014. 21 p. Electronic copies: Available from the ACR Web site .
- ACR Appropriateness Criteria® acute trauma to the knee. Literature search. Reston (VA): American College of Radiology; 2014. 1 p. Electronic copies: Available from the ACR Web site .

Patient Resources

None available

NGC Status

This NGC summary was completed by ECRI on May 6, 2001. The information was verified by the guideline developer as of June 29, 2001. This summary was updated by ECRI on July 31, 2002. The updated information was verified by the guideline developer on October 1, 2002. This summary was updated by ECRI on February 6, 2006. This summary was updated by ECRI Institute on May 18, 2010. This summary was updated by ECRI Institute on August 24, 2011. This summary was updated by ECRI Institute on April 16, 2015.

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